A Star Shaped Superwide band Fractal Antenna for 5G Applications

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***Abstract*—This study proposes a superwide band (SWB) microstrip fractal antenna for 5G communication, using star-shaped elements to create a snowflake-like structure.The fractal geometry. The Rogers RT5880 substrate, which has a thickness of 0.787 mm, a dielectric constant of 2.2, and a loss tangent of 0.0009, is the configuration of the suggested design. The proposed structure's parameters are optimized using CST Microwave Studio to make the given antenna appropriate for operation in the frequency range of 20GHz to 40GHz with a fractional bandwidth of 165percent. The antenna is extremely small, measuring only 20mm by 20mm overall. Gain is gained with a maximum of 10 dBi and an average of 6.4 dBi, and overall appreciated gain is maintained throughout the full range. In the study, result curves for the S-parameter, VSWR, radiation pattern, and gain have been shown and discussed.**

***Index Terms*—Superwideband (SWB), Microstrip patch antenna, Snowflake structure, Star form, 5G technology.**

I. Introduction

Due to its smaller size, lighter weight, lower cost, excellent efficiency, and simple fabrication requirements, microstrip antennas are widely popular. Mobile and satellite communications, radar, the global positioning system, and other technologies all found use for MSA. Future mobile technologies are expected to undergo significant advancements, including faster data transfer rates for sophisticated applications like high-quality audio and video calling, broadcasting capabilities, and online high-quality gaming, among others. As a result of these increased coverage needs, there is a push for the transition from 3G and 4G to 5G communication networks.

In comparison to earlier generations of mobile technology, 5G communication is anticipated to provide data rates that are 100–1000 times greater, hence 5G networks have been proposed to make use of the higher bandwidths to deliver such high data rates. To increase the capacity and data rates, the focus of research has recently switched to millimeter wave frequencies. Consequently, it is anticipated that the 5G network will operate at frequencies greater than 10GHz. Conventional patch antennas fall short in providing high gain, high power handling capacity, and broad bandwidth in addition to the numerous appealing advantages of MSA as discussed above. Ultra wideband (UWB) and super wideband (SWB) antennas may be the best choices for present and future mobile consumers to address these shortcomings.

An UWB antenna runs in the frequency range of 3.1GHz to 10.6GHz, as suggested by the Federal Communications Commission in 2002, and does have a reflection coefficient less than -10dB in the entire spectrum with an average EIRP level of -41.2dBm/MHz [4]. Another restriction states that an antenna qualifies as a UWB antenna if its ratio bandwidth is larger than 1.8:1 and less than 10:1, as well as its fractional bandwidth is greater than 25percent. The antenna is referred to as a super wideband (SWB) antenna if the ratio bandwidth, which is the ratio of the higher cut-off frequency to the lower cut-off frequency, is larger than 10:1. Due to its iterative nature, the usage of fractal geometry is the most well-known technique for achieving such wide bandwidths as in SWB, which allows for SWB without enlarging the total antenna area.

The gradual recurrence of a similar structure at various scales is a characteristic of fractal geometries. Repeating the same structure results in antennas with greater multiband, wideband, and radiation pattern qualities, while the space-filling property of fractal geometries results in a smaller antenna.

Many antennas achieving super wideband (SWB) using fractal geometries have been reported in recent years, including one that proposed two iterations of Sierpinski square slots to obtain a compact hexagonal Sierpinski fractal antenna for SWB applications and achieved impedance bandwidth from 3.4GHz to 37.4GHz, another that used hexagonal loop string geometry to implement a planar super wideband antenna with a reflection coefficient below -10db from 1.18GHz to 49.22. demonstrated a star-triangular antenna with a geometry consisting of a star in a circle with triangular structures over it that operated in the frequency range from 20GHz to 40GHz and had a small overall size of 20mm20mm1mm, demonstrating an antenna with a large bandwidth of 1GHz to 35GHz by making a few changes to conventional antipodal Vivaldi antennas with Chebyshev tapered loading.

Future mobile devices will benefit from the relatively small size and frequency operation of the suggested structure in this article, which is meant to function between 20GHz and 40GHz. The design of the antenna construction, parametric analysis, and result curves as S-parameters, VSWR, gain, and radiation patterns will all be covered in detail in the following sections.

II. Antenna Structure

The fundamental rectangular microstrip antenna underwent eight major evolutions and improvements before the final design of the proposed construction was reached. The primary structure, a straightforward rectangular MSA, is depicted in Fig. 1. (a). Antenna-II, the first improvement made to the results, involves converting the rectangular MSA into a triangular MSA, as shown in Fig. 1(b). This improvement is then followed by Antenna-III, the development of the previous structure, which repeats the triangular structure to create a star shape, as shown in Fig. 1(c). Finally, the basic star-shaped structure is then repeated on the five corners of Antenna-III, which is the (h).Using CST Microwave Studio, each of the eight stages was separately simulated. The consequences of the evolutions can be seen in the result curve. Further resonance frequencies are discovered and S-parameter values below -10dB are attained with subsequent rounds and evolution. To model the structure, a defective ground plane is employed, and Rogers RT5880 with a thickness of 0.787mm, dielectric constant of 2.2, and loss tangent of 0.0009 is used as the substrate. Final dimensions are obtained in Table-I. The antenna has an overall dimension of Wsub(20mm)Lsub(20mm). This small size is made possible by the antenna's high operating frequency and star-shaped fractal structure.Each parameter was examined within its precise predicted range, and the design was encouraged to produce curves for various values. The next subsections provide a graphical representation of the parametric analysis of three of the design parameters that have the greatest impact on the S-parameter curve. To gain a clear observation of curves, a frequency range of 20GHz to 40GHz is used..The parametric information are listed in the tabular form.

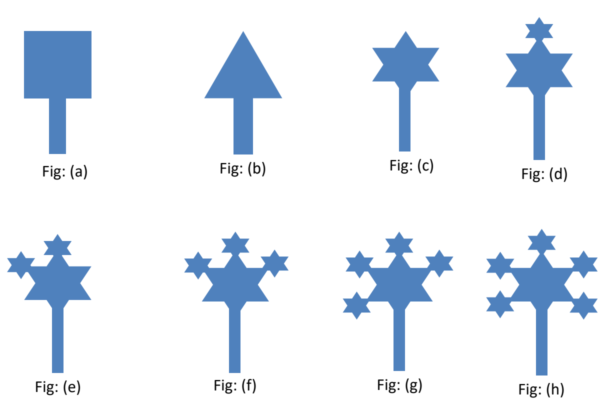


Fig. 1: (a) Antenna-I; (b) Antenna-II; (c) Antenna-III; (d) Antenna-IV; (e) Antenna-V; (f) Antenna-VI; (g) Antenna-VII; (h) Antenna-VIII.

TABLE I: Dimensions of Designed Antenna

Parameter	**Value**
Wg	12.9mm
Lg	10.7mm
Wsub	20mm
Lsub	20mm
A	8.3mm
h	0.787mm
Ls	8.4mm
R	3.05
Ws	2.8mm

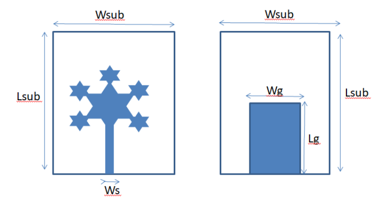


Fig. 2: Final structure with the dimensions. (a) Patch(Front View) (b) Ground(Back View)

III. SIMULATED RESULT AND ANALYSIS

It includes S-parameter,VSWR,Gain,Directivity,Bandwidth etc.

A. S-parameter

S-Parameter is also called as return loss or Reflection Coefficient and is denoted by (S11). The performance of antenna generally depends upon a good reflection coefficient or return loss of at least -10 dB or greater than -15 dB because return loss in antenna is a ratio of incident power to that of reflected power. As shown in "Fig. 3", it has seen that the return loss is -24.627 dB for 28.58 GHz frequency and -26.921329dB for 34.54GHz frequency.

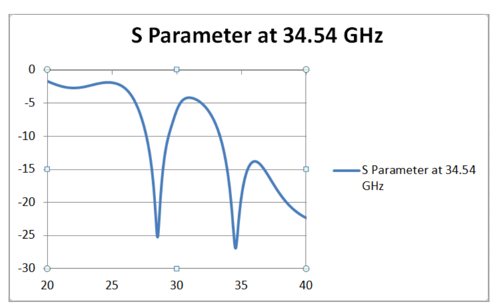


Fig. 3: S-parameter of the Antenna-VIII

B. Voltage Standing Wave Ratio(VSWR)

The voltage standing wave ratio is also known as standing wave ratio. For microstrip patch antenna design to be used for 5G applications, the standard values of VSWR are less than 2. This ratio is always considered as real and positive real number. Higher the value of VSWR indicates greater the mismatch.The achieved values of VSWR are 1.1 and 1.09 in

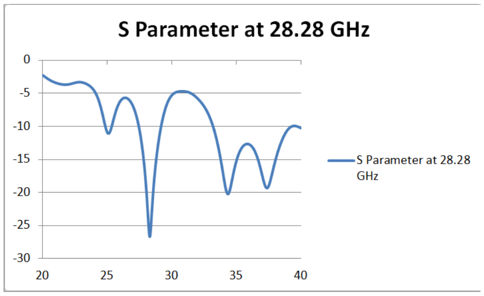


Fig. 4: S-parameter of the Antenna-VII

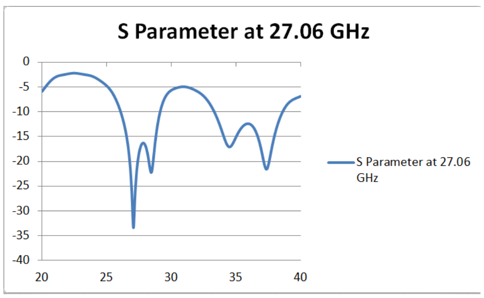


Fig. 5: S-parameter of the Antenna-VI

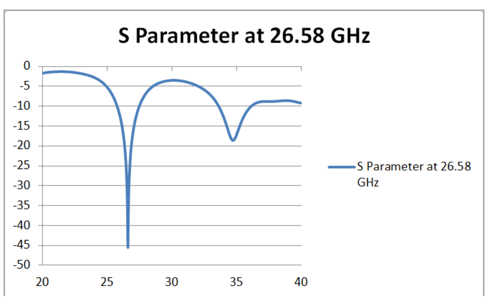


Fig. 6: S-parameter of the Antenna-V

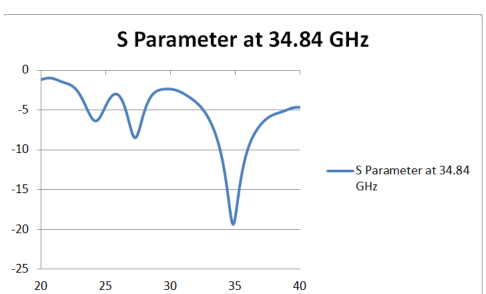


Fig. 7: S-parameter of the Antenna-IV

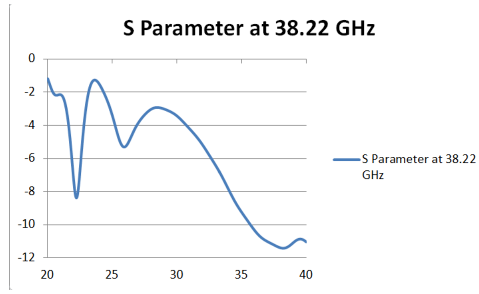


Fig. 8: S-parameter of the Antenna-III

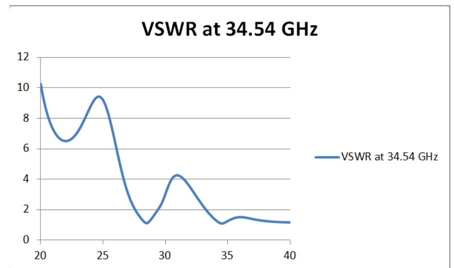


Fig. 9: VSWR of the proposed Antenna

the respective operating bands as shown in "Fig. 9". Hence, the antenna has good transmission characteristics.

C. Radiation Pattern

- Gain: Gain is a much required characteristics for Wi-Fi system because this radiation patterns indicates the quantity of power radiated by antenna.The achieved gain for the lower band is 7.208 dBi and for the upper band is 10.91 dBi."Fig. 10" shows the gain plot for broadband.
- Directivity: Many antennas and optical systems are designed to radiate electromagnetic waves in a single direction or over a narrow angle which is why directivity is another important characteristic. Directivity was found 7.201 dBi and 10.84 dbi for respective frequencies as shown in "Fig. 11a" and 11b .

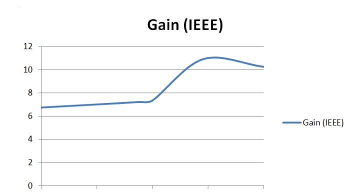
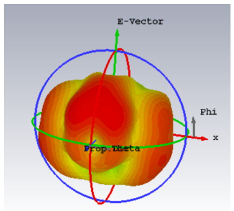


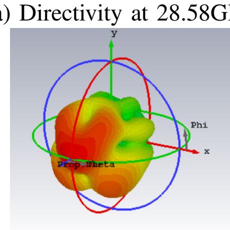
Fig. 10: Gain of the proposed Antenna-VIII

D. Farfield Pattern

"Fig. 12a" and "Fig. 12b" depicts the directional pattern of the Far-field antenna. Two-dimensional (2D) radiation patterns represent the co-polarization and cross-polarization at 28.58 GHz and 34.54 GHz. The phi and theta fields indicate the cross-polar and co-polar components at 28.58 and 34.54 GHz, respectively. It is seen that the cross polarization effect is

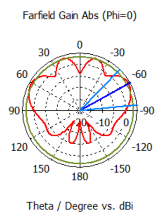


(a) Directivity at 28.58GHz

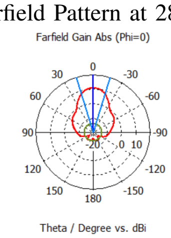


(b) Directivity at 34.54GHz

Fig. 11: Directivity of the proposed antenna-VIII



(a) Farfield Pattern at 28.58GHz



(b) Farfield Pattern at 34.54 GHz

Fig. 12: Farfield Patternof the proposed antenna-VIII

higher in 6GHz than the other frequency. By analyzing the radiation pattern, the graph shows one loop shaped plane, and another plane is circular, which shows that the antenna has extraordinary Omni-directional characteristics.

IV. Comparison with existing Star shape fractal base antenna

TABLE II: Comparison Table

Antenna	Frequency	S-Parameter	Gain
Antenna-III	at 38.22GHz	-11.412dB	6.026dbi
Antenna-IV	at 34.84GHz	-19.349dB	8.858dbi
Antenna-V	at 26.58GHz	-45.492dB	8.134dbi
Antenna-VI	at 27.06GHz	-33.388dB	5.968dBi
Antenna-VII	at 28.28,34.331GHz	-26.673,-20.216dB	6.917,7.380dbi
Proposed Antenna	at 28.58,34.54GHz	-24.886,-26.903dB	7.208,10.91dbi

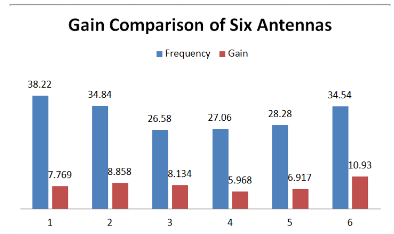


Fig. 13: Displays simulated gain at various stages

V. Conclusion

The study includes an illustration of a SWB fractal antenna with a super broad frequency range of 20GHz to 40GHz. For a 50 Microstrip line, impedance matching has been obtained.because the reflection coefficient is below -10 dB throughout the whole frequency range. Parameter, VSWR, radiation pattern, and gain result analyses have been completed and discussed.It has been observed and maintained that the maximum gain is 10dBi and the average gain is 6.4dBi across the frequency range. The proposed antenna may have various uses in the future, including in satellite systems and mobile applications.Further advancements will allow for the fabrication of simulated structures, the variation of measured results, and the construction of arrays with improved gain and radiation characteristics.

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